

CLAIMS

1) A method of estimating, from data obtained by exploration of a zone of a heterogeneous medium, a model representative of the distribution, in the zone, of at least one physical quantity, this model being free of the presence of correlated noises
5 that may be contained in the data, characterized in that it comprises the following stages :

a) acquisition of measurements giving information about certain physical characteristics of the zone by following a predetermined experimental protocol,

b) specification of a modelling operator which associates, with a model of each
10 physical quantity, synthetic data that constitute the response of the model, the measurements and the synthetic data belonging to the data space,

c) for each correlated noise referenced by a subscript j ranging from 1 to J , selection of a modelling operator which associates a correlated noise with a noise-generating function belonging to a predetermined noise-generating functions space (B_j),

15 d) specification of a norm or of a semi-norm in the data space,

e) specification of a semi-norm in the noise-generating functions space for which each noise modelling operator establishes substantially an isometric relation between the noise-generating functions space and the data space,

f) definition of a cost function quantifying the difference between the
20 measurements on the one hand and the superposition of the model response and of the correlated noises associated with the noise-generating functions on the other hand, and

g) adjustment of the model and of the noise-generating functions by minimizing the cost function, by means of an algorithmic method taking advantage of the isometry properties of the noise modelling operators.

2) A method as claimed in claim 1, wherein the distribution as a function of depth
5 of the acoustic impedance in the medium is sought, the correlated noises affecting the data are tube waves identified each by parameters characterizing their propagation, the measured data are VSP data obtained by means of pickups suited to detect the displacement of particles in the medium in response to a localized seismic excitation, the location of the pickups, the recording time and the time sampling points being
10 defined, and the modelling operator selected associates the synthetic data with an acoustic impedance distribution as a function of the evaluated depth in traveltime and with the vertical stress measured as a function of time at the depth of the first pickup.

3) A method as claimed in claim 2, wherein the cost function quantifying the difference is the square of the semi-norm of this difference in the data space.

15 4) A method as claimed in claim 2 or 3, wherein adjustment of the model and of the noise-generating functions is obtained by means of a block relaxation method for eliminating the unknowns corresponding to each correlated noise generating function, this relaxation method being implemented within the iterations of a quasi-Newtonian algorithm for calculation of the model.

20 5) A method as claimed in any one of claims 2 to 4, wherein numerical calculation of the image of a model by the modelling operator is carried out by numerical solution of the 1D waves equation for the model considered, by selecting values taken by the displacement of the particles at the locations of pickups and at the previously defined

time sampling points, and by applying an operator likely to compensate for the spherical divergence and attenuation effects.

6) A method as claimed in any one of claims 2 to 5, wherein the numerical noise modelling operator is a finite-difference centered numerical scheme for discretizing the noise transport equation, and the noise-generating function involved as the initial condition along the edge of the observation zone belongs to a space (B_j) consisting of the support time functions in a give time interval.

7) A method as claimed in any one of claims 2 to 6, wherein the semi-norm selected for the data space is :

$$\|u\|_D = \left(\Delta x \Delta t \sum_{i=0}^{I-1} \sum_{n=0}^{N-1} \frac{1}{\tau^{n+\frac{1}{2}}} (u_i^{n+1} + u_i^n)^2 \right)^{\frac{1}{2}}$$

10

and the semi-norm selected for the noise-generating functions space is :

$$\|\beta\|_B = \left(\Delta x \Delta t I \sum_{n=0}^{N-1} \frac{1}{\tau^{n+\frac{1}{2}}} (\beta^{n+1} + \beta^n)^2 \right)^{\frac{1}{2}}$$

8) A method as claimed in claim 1, wherein the distribution of disturbances, in relation to a previously selected reference model, of the impedance and of the velocity in said zone of the medium is sought, the correlated noises affecting the data are due to multiple reflections whose kinematics and amplitude variations with the offset have been previously estimated, the measured data are picked up by seismic surface pickups,

15

the location of said pickups, the seismic excitation mode, the recording time and the time sampling points being defined, and the modelling operator being defined via linearization of the waves equation around the reference model.

9) A method as claimed in claim 8, wherein the cost function quantifying the
5 difference is the square of the semi-norm of this difference in the data space.

10) A method as claimed in claim 8 or 9, wherein adjustment of the model and of the noise-generating functions is obtained by means of a block relaxation method for eliminating the unknowns corresponding to each correlated noise generating function, this relaxation method being implemented within the iterations of a conjugate gradient
10 algorithm for calculation of the model.